Industrial Structure Council

Commerce, Distribution and Information Committee

Information Economy Subcommittee

Interim report

- Changes in response to the arrival of a data-driven society using CPS -

May 2015

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1. Introduction

In history, one of important factors that has driven the development of humankind and society is definitely information. Starting from cave paintings forty thousand years ago, technological innovations such as the invention of paper in 105 A.D., typography in 1450 and telephone in 1876 that enable us to acquire, record, deliver and process information, have been created over a long period of time, which have contributed to human society's non-continuous development from the past to the future.

This was accelerated following the invention of computer in 1950, leading to IT innovations including Internet in 1970, World Wide Web in 1993 and smartphones in 2007. First mainframe/VAN (Value Added Network) triggered structural changes in business to the main use of computers. Then with widespread use of the Internet, digitalization and networking have been seen in not only the business world but also the general public, and with further use of mobile devices, the spread of digitalization and networking becomes not only wider but also deeper, leading to deepening of personal use.

In these circumstances, with the ongoing technological innovation of IoT (Internet of Things), digitalization and networking not only for humans but also for things have been rapidly growing, and Cyber Physical System (CPS) has been realized, with which the state of the real world can be directly transferred to the cyberspace through not humans but data, and the results of information processing in the cyberspace can control the movement in the real world. With the explosive growth of data traffic according to this circumstance, the use of big data and artificial intelligence has been accelerated, which may cause further changes in corporate and individual behavior patterns, resulting in business model innovation opportunities around the world. This is the third innovation following the use of computers and the spread of the Internet in a technology revolution that may change the basic competitive structure in the industrial society; therefore sticking to the existing business practices prevents our country's major industries from responding to this change, which may lead to a significant decrease in the international competitiveness.

For example, in the IT industry, the central role of information processing is already shifting from the client to the cloud (server), and consequently "elaboration" business activities for systems and devices that Japan's IT companies have adopted are standardized and opened, resulting in a significant decline in the global competitiveness. This shows the possibility that the declining trend may be accelerated with the accelerated deepening of CPS.

On the other hand, in other industries, many people disagree with the view that all

information processing will be transferred to the cloud and on-site added value will decrease in the industry, and there is still the view that an environment will be provided to use advanced information services at a lower cost, which can create more business opportunities. In these environmental changes, however, if no management innovation is made to support and implement general-purpose technological innovations in the cloud, competitiveness may be lost in many industries as in the IT industry.

The way to prevent the above is that individual companies change the managerial mindset so as not to stick to the conventional business practices, concentrate their management resources on their strong points, and collaborate with others who have other strong points to create an ecosystem departing from Not Invented Here syndrome.

The government will provide support to companies for re-focusing their business strategy by making Japan a “testbed” in which companies can take a quick trial-and-error approach through active inter-firm relationships. Concretely speaking, consistent efforts are required, through which we review the systems according to social changes, and the industry world re-develops industrial practices on its own based on the reviewed systems, and then the government, industry and academia develop supplementary social infrastructures including security, technology and human resources together. Taking advantage of Japan’s strengths strategically, the government, industry and academia will lead the world in achieving an unconventional data-driven society using CPS through strong relationships.

2. A coming data-driven society using CPS

2.1. New information revolution: Cyber Physical System (CPS)

The rapid expansion of the Internet in the latter half of the 1990’s brought about the wave of informatization in the whole society. In the conventional “information society”, however, almost all information created in society every day are stored in an analog format, and only some information are digitalized according to the specific purposes. Additionally respective data are stored at many different places and used mostly within a local network. As seen above, what that prevents us from collecting, accumulating and analyzing digital data is physical restrictions such as functions/costs, communication capacity and storage capacity.

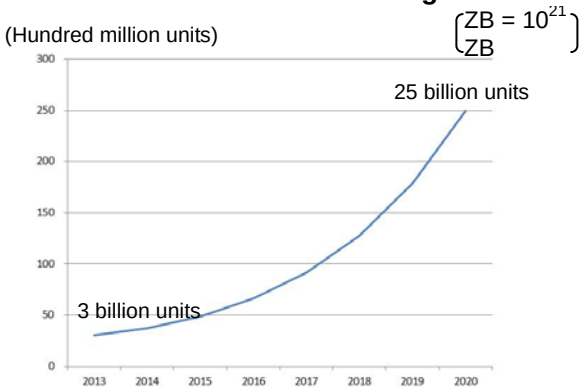
However, the recent development of IT technologies is remarkable, and as for devices,

downsized, energy-saving and cheaper sensors and advanced mobile devices are now available while as for information processing, large-scale and cheaper cloud systems and advanced distributed processing technology have been developed. Besides, as for network, higher communication rate and cheaper communication cost are achieved.

With rapid innovation in technologies, costs for digitizing different data have been lowered. Accordingly IoT to connect everything in the real world over the network has been in progress, and previously non-digitized and scattered data start being distributed in high volume via the Internet. Even referred to as “information explosion”, the volume of data distributed across the society is increasing faster and faster, which allows a large volume of, highly-frequent and highly-variable big data to be used in various fields.

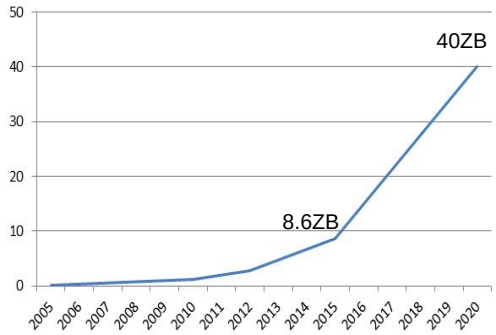
Consequently, collection, accumulation and analysis of digital data and feedback of analysis results to the real world that could not be achieved previously are now possible, and the interrelationship between the real world and cyberspace (CPS) is being developed, which allows us to foresee the movement of social change that can be a new information revolution.

<Fig. 1: Trends in the number of connected devices using IoT>



Sources: Prepared by METI based on materials published by Gartner

<Fig. 2: Volume of data distributed across the world>



Sources: Prepared by METI based on materials published by IDC

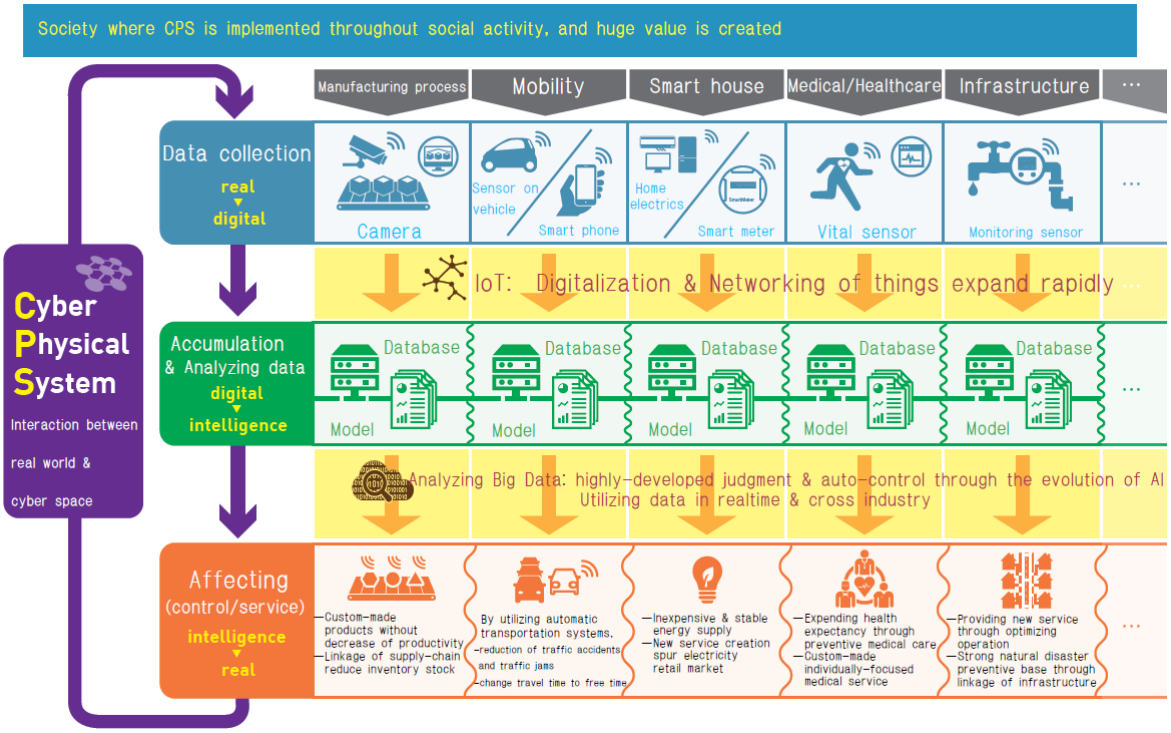
A movement is occurring to respond to these circumstances in the world. In Germany, the “Industry 4.0” strategy has been applied since 2011 to achieve the total optimization of the development, manufacturing and distribution processes using IoT, in which a lot of companies including Bosch, Siemens, ABB and SAP are participating. In U.S., GE proposed the “Industrial Internet” that enables sophisticated decision-making through data analysis by connecting industrial equipment to the Internet, and Cisco, IBM and Intel that own the de facto standard in each layer and

other 100 or more companies including several Japanese companies are forming the Industrial Internet Consortium (IIC).
In the future, as artificial intelligence improves, a more sophisticated judgment can be made in digital data analysis, and fully autonomic and intelligent automation of feedbacks of analysis results to the real world can be achieved, leading to more profound social changes.
The below is a summary of what's mentioned above that reveals that the implementation of IT in society is following the following steps and is currently in Degree IV, achievement of CPS.

Degree I	Use individual devices independently (standalone) (- in the latter half of the 1990's)
Degree II	Connect some devices to the network to distribute digital data (networking) (- in the first half of the 2000's)
Degree III	Transfer the functions including data accumulation, collection and processing from individual devices to data centers on the network (cloud computing) (- in the latter half of the 2000's)
Degree IV	Create a loop to convert the real world into digital data, process such data and then send feedbacks to the real world (CPS) (from around the 2010's)
Degree V	Create value and achieve fully autonomic and intelligent automation using AI (in the future)

Our vision for a future society is information society that can be realized by implementing CPS, which interrelates the real world and cyberspace, across all areas in society to create greater social value, and it is important for us to lead the world by establishing a data-driven society using CPS to maintain our economic competitiveness in the age of intense global competition caused by a new information revolution.

<Fig. 3: Conceptual diagram of a data-driven society using CPS>



<Ref.: Definition of the keywords in this report>

- **CPS:** Cyber Physical System. Relationship between the real world and cyberspace to collect, accumulate and analyze digital data and to send feedbacks of analysis results to the real world. This concept is synonymous with Germany's fourth industrial revolution (industry 4.0) but actually focusing on approaches in the production process.
- **Data-driven society:** where the above-mentioned CPS is applied to various industrial societies through digitization and networking of things using IoT, and the digitized data is converted into intelligence and applied to the real world, and then the data acquire added value and move the real world.
- **IoT (Internet of Things):** Connection from various things to the Internet. In the above CPS process, this refers to the digitized real world using sensors that is distributed over the network. IoT refers to networking everything (not only things but also events), or not only distributing data but also controlling the real world, which is almost synonymous with CPS but used in a limited sense here.
- **Big data:** In the above CPS process, this refers to the accumulation of digital data characterized by their large quantity, high frequency and diversity.
- **Artificial intelligence (AI):** Software that replicate the same function as the human thought. Many technologies have been developed depending on different purposes and techniques, and especially the technology called "deep learning" derived from "machine learning" is an autonomous learning technology that "abstracts and extract patterns" using cases (data), and learn and gain knowledge on its own. Those who can use sophisticated AI with this technology and make a rapid and accurate decision for creation of value will predominantly dominate the competition in a wide variety of industries.

2.2. IT innovations that contribute to deepening of CPS

The level of technology required to encourage the deepening of the implementation of IT in society for successful CPS vary depending on the degree of deepening. Therefore future industrial competitiveness and social change greatly depend on success or failure of efficient and intensive component technologies development for deepening CPS.

Well-balanced deepening of the technologies below and new industries created by appropriately combining these technologies are essential for creating a virtuous cycle, that is to say, data on everything in the real world is digitized (collected/accumulated), the digitized data is distributed (delivered) via the Internet, processing and analyzing the data create new added value, the created value brings about changes in the real world and such changes are collected as data.

(i) Information processing/analysis
Related technology: cloud computing, Data anonymization, artificial intelligence, machine learning etc.

(ii) Network (information delivery)
Related technology: high capacity communication, switch, router, Ethernet, TCP/IP etc.

(iii) Device (information collection/accumulation, control etc.)
Related technology: sensor (image, acceleration rate etc.), measuring equipment, system LSI, memory, hard disk etc.

The deepening of the implementation of CPS is in progress in individual organizations and industries, and in the whole society at different speeds. Actually costs for high-performance components/technologies including sensors have been reduced according to the progress of the implementation in the industry field, leading to a gradual spread at the organization level. With regard to the process of the deepening, it is important to forecast on an entity basis, or by organization or industry to take appropriate responses.

2.3. Impact on industry and society from CPS

According to the degree of deepening of CPS, the following changes can be mainly made in the industrial field and society. These changes may have a discrepancy with the existing industrial structures or social systems, and in order to enjoy the maximum benefit from the deepened CPS, reform of industrial practices, changes in industrial policies and review of restrictions in fine detail are essential according to the degree of deepening of CPS.

(1) Creation of high added value by interaction between the real world and cyberspace

CPS-related changes can create new added value such as innovation of processes and operations in different industries and advanced business models including “commercialization of products” in various fields including manufacturing process, mobility, distribution, smart house, medial service/health, infrastructure/industrial safety and public administration. In addition, we have been living in a mass production and mass consumption society where product or service suppliers unilaterally provide almost the same products or services to users, and if users ask suppliers to completely meet their specific needs, users must pay a considerable amount for so-called tailor-made products or services. In the future, however, we will live in a newly-changed society where, with the use of data owned/sent by individuals or organizations as a user, suppliers can provide their products or services at low costs that meet users’ specific needs in detail. In this society, users can take the initiative in determining which product or service is provided to which user, and creation of added value will be driven by users. Additionally with increased information processing resources available according to further improvement of virtualization technology, availability of new services using information will increase both qualitatively and quantitatively, and a source of added value may greatly shift from things to services. For example, analyzing and using data acquired from the sensor installed in equipment/facilities, GE developed “Predix”, an application to take advanced control of equipment/facilities, which is provided to 24 fields including petroleum gas, electric power, water, transportation, aviation and medical services.

As the deeper CPS becomes, the higher the autonomy of the system, the system may replace the role of humans in the middle- and long-term.

(2) Creation of new added value through the secondary use of data or application of technology infrastructure in specific fields to other fields

All information acquired, digitized and distributed in a standardized format can create new services or products in each field while applying technology infrastructure in a field to other fields can create completely new added value beyond the boundaries of existing industries, which stimulates destructive innovation, resulting in some great changes in a wide variety of industries.

As one example of these approaches, recently Google is aggressively buying non-software related companies such as robotics-related companies and intelligent consumer electronics companies, and is continuing its research and development of self-driving cars without a steering wheel, which is an expansion into the real world.

On the other hand, due to distributed and integrated information in various fields, individual information can be exposed to others more frequently than ever, and rights to control information about ourselves may be lost and the originator of data may be identified.

(3) Horizontal specialization according to the promoted digitization, changes in development/production methods, and appearance of economies of scale and network externality

Digitizing the real world increases the reproducibility of the real world using digital data, this increased reproducibility, however, is highly likely to change the value of so-called “coordination” and to promote the modularization and horizontal specialization.

On the other hand, use of new methods including module production and module-based system engineering (MBSE) for development and evaluation using virtual simulation can be promoted at the development/production site. These new methods allow developers to cooperate in developing diverse and advanced products required by societal demand or customers, and in responding to complicated design/development operations due to a shortened product life-cycle, and can drastically improve the efficiency of development/production and function/performance that cannot be achieved by “coordination” that is conventionally implemented using a prototype.

As new methods such as modularization and MBSE spread, the capability and evaluation axis required for each module are indicated explicitly, which increases the comparability and selectability between competitors and promotes competition for advancement in performance. Meanwhile if there is little room for differentiation, the evaluation axis is limited, which may cause overcompetition/excessive competition due to severe price competition, leading to a decrease in financial strength of

companies. Especially system suppliers are strengthening their presence by aggressively promoting modularization broadly grouping the systems by part by means of MBSE while small and medium-sized companies may lose their competitiveness without adapting to methods using digitization.

If these changes take place, economies of scale have a strong influence on modules including software in a new market and greatly contribute to cost reduction of advanced solutions, bringing universal benefits to small and medium-sized companies and consumers. On the other hand, as the advance of digitization can speed up the development cycle, increase the deliverability of technology development results and make outsourcing production easily, for the products that once met social needs and have little room for differentiation from which added value is created, commoditization and horizontal specialization have proceeded, which may lead to overcompetition/excessive competition. In this case, the specific field may have a reduced ability to create innovation and negative impact on the power of the economy as a whole.

In addition, in the field where data is concentrated in specific companies, data becomes a big source of added value, and network externality that will have a higher advantage according to increased number of entities participating in the network, has a strong influence, which may greatly change the conventional competitive environment and lead to monopoly/oligopoly situation by specific companies.

For example, in the electronics industry, Japanese companies could show their power by supporting from design to manufacturing with their proprietary facilities (vertical integration) for retaining customers, however, as internationally vertically-specialized ecosystems were organized with developed digitization and modularization and increased investment scale, which boosted global competition in each layer, Japanese companies could not adapt to this structural change and fell behind in cost and performance.

(4) Increased security risk and compliance risk

In society where a large amount of information is shared on a common platform, personal information and data collected from sensors can be a big source of added value while the following risks increase: risks of destruction and violation of the information system by malicious users including cyber-attacks; and corporate compliance risks of leakage of owned personal information, and unauthorized acquisition/use of intellectual properties. As CPS deepens, important information owned by one company increases, which motivates malicious users to illegally steal information by cyber-attacks.

In some latest cyber-attacks, we cannot detect any leakage of information, or if detected, identification of leaked information is difficult. Without completely defensive security measures, decentralized response on a company basis is not enough and costs for measures can be huge. In addition, linking or concentrating data between several companies or devices increases the number of stakeholders involved in one system, which cannot guarantee appropriate security measures, imposing a significant obstacle to deepening of CPS in society.

Under these circumstances, other countries are taking public-private partnership-based measures against sophisticated cyber-attacks, and in order to reduce risks, the government is taking the initiative in constructing a network to share cyber-attack information and developing and informing of measures and guidelines to follow.

For example, in U.S., an Executive Order was issued to encourage companies to enhance and promote independent cyber security measures for important infrastructure in February 2013, and accordingly NIST (National Institute of Standards and Technology) under the Department of Commerce developed “Framework for Improving Critical Infrastructure Cybersecurity” in February 2014. In order to promote corporate use of this framework, the Department of Homeland Security (DHS) is studying incentive plans including the use of cyber insurance while holds a public-private forum to share issues with the use of the framework. In February this year, another Executive Order was issued to order the development and promotion of a network to share cyber-attack information between the public and private sectors, and DHS will start providing support for constructing the network while a new organization to promote sharing of cyber-attack information will be installed in the White House.

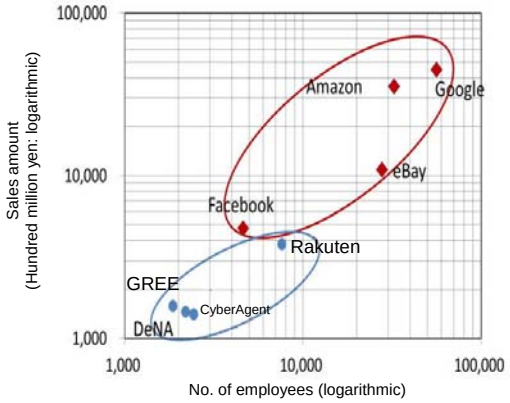
In a phase where CPS is being deepened, if appropriate measures are not taken by watching the movements of other countries, Japanese industry’s low ability to cope with cyber-attacks may lead to low reliability.

3. Issues in realizing a data-driven society using CPS

With the progress of IoT, the movement of CPS will spread globally in different fields with some differences in speed. As mentioned above, in the field in which CPS is expanding, economies of scale and network externality have a strong influence, and those who presented a grand design and established an ecosystem first have a high possibility to capture added value.

Previously Japanese companies, however, made a slow response to introduce the Internet, social network and mobile devices, consequently in a new platform-based business using IT, such as e-commerce and SNS etc., even companies that have a certain share in the domestic markets cannot gain enough global market share, and US companies are developing worldwide platforms.

<Fig. 4: Comparison of sales amount and employment between major Japanese and US IT companies>



Sources: Prepared by METI (2012)

In order to respond to this situation, we need to make Japan a venue for business innovation that creates a stream of CPS-related new businesses, and to create a virtuous cycle by attracting people, goods and capital in the world including foreign global players and globally expanding new business from Japan.

To achieve the above, we have to resolve the following issues:

3.1. Necessity of review of the current systems that do not support CPS

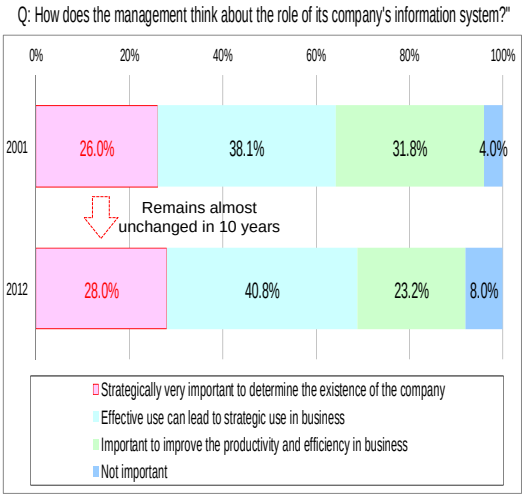
Due to a structural change or CPS, there is a gap between existing systems including business regulations not based on IT innovations and the real world, and it is inevitable that gray areas occur when a new business model is created. Additionally

there is no legal framework for cross-company data distribution, which interferes with movement toward data linkage between companies. Especially for personal data that is expected to be used properly, use of data may conflict with information privacy; therefore we try to achieve the best possible balance between the two.
US companies take the approach that they move into these gray areas first to immediately recover their investment (if any problem occurs, they enter into a legal battle) while Japanese companies have a strong tendency to defer a decision on commercialization from the perspective of emphasizing compliance, greatly falling behind in rapidly dominating the market and constructing an ecosystem.
Thus it is important to immediately develop necessary rules as a soft-infrastructure for implementation of CPS to businesses (CPS businesses) to define the relationship with the existing regulations and the secondary use of data that may affect the privacy.

3.2. Significance of user-driven approaches to industrial practices supporting CPS

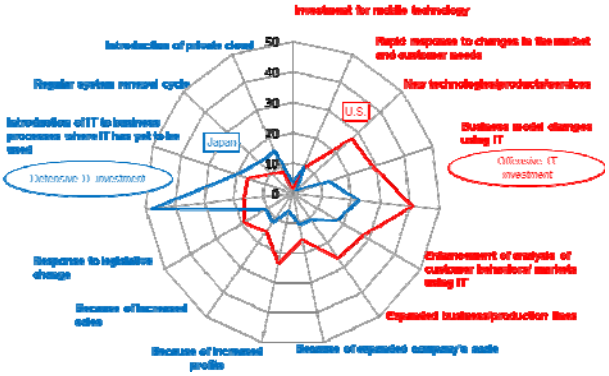
In response to a structural change or CPS, we need to make a clear distinction between competition area and collaboration area, and promote the efforts by the industry on its own to create practical business models. Previously Japanese companies have failed to concentrate their resources into competitive area while failed to collaborate with other companies in collaborative area, having experienced repeated failures, i.e. “Win the manufacturing but lose the business”.
For example, with regard to mobile devices, they became commoditized and the source of added value shifted from the capability of the device to services. Apple and Google are constructing a platform for mobile OS as a layer to connect devices to services, which is an oligopoly market structure.
In the face of changes in the global competitive environment, Japanese companies are still taking a defensive stance that IT and data are tools to improve operations, and have yet to use IT and data strategically for management, leading to delay in change to offensive business model to maximize their competitiveness without bold and agile selection and concentration of businesses suited to the times.

<Fig. 5: Management's awareness of IT in Japan>



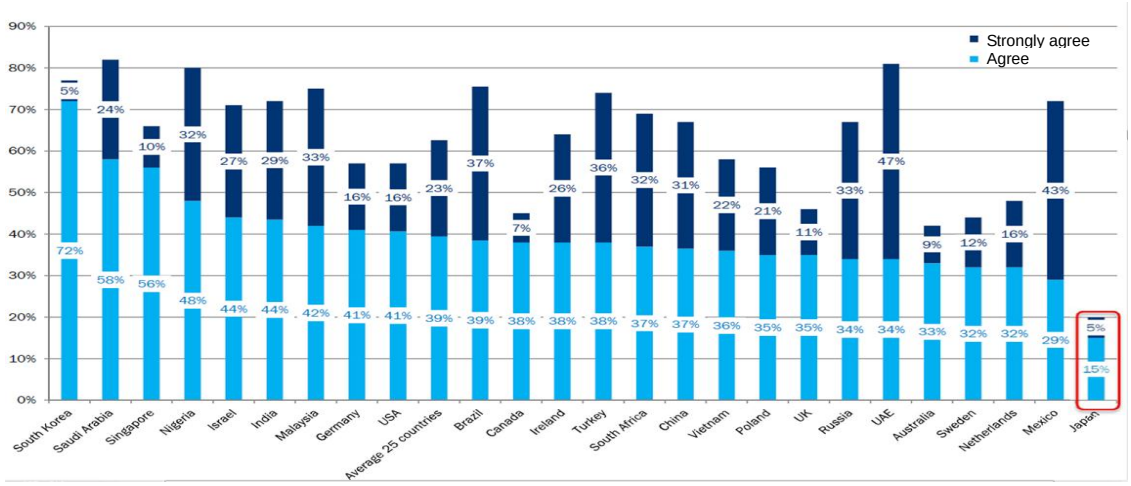
Sources: "IT Strategy promotion trend survey" ITR (2001 & 2012) (200 domestic companies)

<Fig. 6: Intended use of increased budget in the companies in which IT budget is increased>



Sources: Japan Electronics and Information Technology Industries Association (JEITA) Survey results from "Analysis of differences between Japanese and U.S. companies in management using IT" (Oct. 2013)

<Fig. 7: Percentage of companies that answered they are using data for innovation>

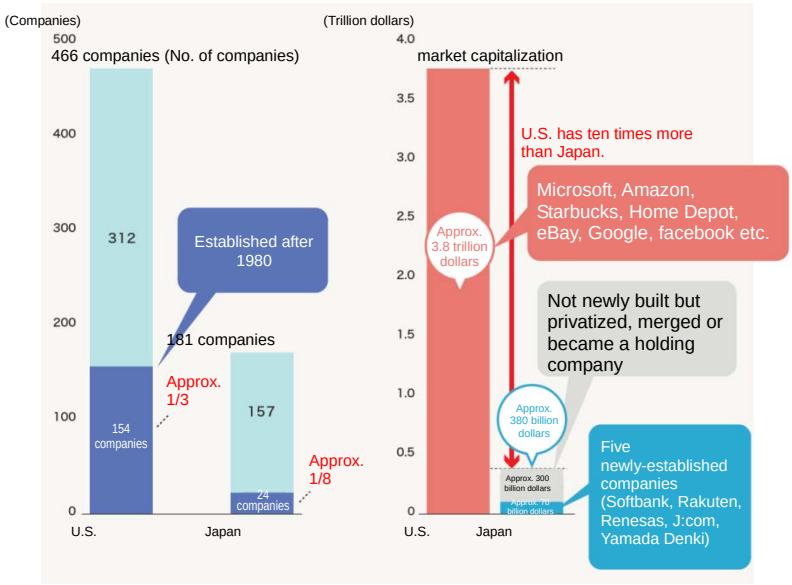


Sources: "GE Global Innovation Barometer 2013 World business leaders' survey"

In order to create new businesses, the key is the existence of startup companies that take innovative approaches without fear of taking risks. In Japan, however, startup companies as a game changer have yet to be grown in comparison to U.S.

<Fig. 8: Comparison in the number of companies that were established after 1989 Out of Forbes

Global 2000 Companies (except for financial companies)>



Sources: Summarized materials for Venture Experts Meeting

As mentioned above, in CPS businesses, it is necessary for companies to leverage their own strength while collaborate with other companies to create an ecosystem to reduce investment costs. As users have a larger role in creating added value, we need to shift from “sellout type business” to “platform type business to retain customers”. For this, user-driven approaches are important to achieve rapid and flexible value creation with which suppliers can meet user’s needs.

CPS businesses are not businesses developed in a linear fashion from the past, in which trial-and-error approaches are important to create concrete industrial models in inter-firm collaboration, and we need to make rules related to standardization, privacy and security as software through these approaches. Especially for B2C (business-to-consumer transaction), development of a trust relationship between companies and individuals is essential, and with the use of multi-stakeholder process (to build a consensus through discussions among the different parties) that is going to be included in a revised personal information protection bill submitted to the current Diet session, parties involved need to hold a dialogue to clearly identify advantages and disadvantages and formulate voluntary rules for privacy and security requirements.

Thus it is vital to share a common situation awareness and sense of danger while create concrete industrial models, make rules by promoting collaboration between companies and send feedbacks to horizontally identify issues.

Both shift to “offensive IT management” using IT and data as business strategy driven by the management with strong leadership in major companies and creation of startup companies that can develop new business models are predicated on inter-firm

collaboration.

3.3. Necessity of enhanced social infrastructure supporting CPS

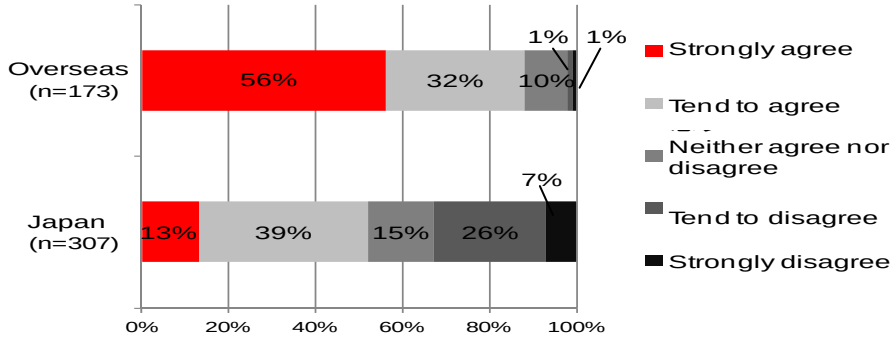
(1) Enhancement of information security

A large part of cyberspace consists of private companies; therefore measures taken by private sectors are absolutely critical. Due to sophisticated cyber-attacks that exploit personal information and intellectual properties, cyber risks an extremely serious threat to management, and in order to defend against increasingly sophisticated cyber-attacks, the management needs to understand possible cyber risks and make decisions on investment for management resources including facilities, structural development and human resources education to improve the organizational ability.

Meanwhile in order to respond to these cyber-attacks, companies need to know the methods of and measures against cyber-attacks, and share and improve the measures, decentralized measures on a company basis, however, are not enough and significantly costly. Same as other countries, the Japanese government needs to take the initiative in developing an information sharing system and guidelines for action against cyber-attacks across the public-private and industrial boundaries to give incentives to encourage private companies to take appropriate measures. At the same time, enhancing the government's response capabilities in case of security incident at a private company is important especially for critical infrastructures. In addition, measures for management of internal fraud are required in light of the lessons learned from the large-scale incidents of personal information disclosure occurred last year.

<Fig. 9: Awareness of security threats at top management level in Japanese companies>

Q: "Do protective measures against cyber-attacks have to be discussed at the board member level?"



Sources: KPMG, Security Survey 2013

(2) Enhancement of research and development of core technologies

Core technologies supporting CPS include information processing/analysis technology using AI, security technology and device technology such as sensors and memories; therefore Japan has to strongly focus on research and development in these fields.

In order to capture the future market associated with these technological innovations, U.S. is strengthening prior investment in research and development in both the public and private sectors. In U.S., the Defense Advanced Research Projects Agency (DARPA) of the Department of Defense is carrying out research and development regarding national defense regardless of fields with the budget of 2.8 billion dollars in 2014. The R&D results including real-time translation and voice assistant app Siri are used also for commercial products. With regard to private companies, for example in the AI field, Google acquired deep-learning development-related company and brought a world authority on board while IBM made an aggressive investment of about 1 billion dollars in enhancing its solution businesses using its AI “Watson”.

On the other hand, in Japan, “improvement of existing technologies” accounts for approximately 90% of private company’s R&D, and the percentage of middle- and long-term R&D that needs a technological leap of 5 to 10 years to commercialization is only 10% even though there is a market for them, being dependent on existing industrial structure or technological trends without middle- and long-term investments. In CPS businesses featuring cross-field collaboration, relationship with other companies will encourage advanced technologies that have yet to be fully used in a variety of fields to be new strong points of Japanese companies.

As mentioned earlier, for respective component technologies from data collection to feedbacks to the real world, well-balanced technological innovations are required, and both enhancement of R&D and efforts for promoting implementation of core technologies in society are essential.

(3) Enhancement of human resources

The trends concerning IT human resources is facing a growing shortage of conventional SE due to a large-scale modification of financial systems and start of the national identification number system, and this situation will continue until about The Tokyo 2020 Olympic and Paralympics Games, and after that, demand for IT human resources will decrease. On the other hand, Japan will face the shortage of IT human resources different from conventional SE on a middle- and long-term basis according to full-fledged arrival of a data-driven society using CPS and increased business

needs in new Web- and cloud-related technology areas. In addition, we also have to take measures for decrease in demand for IT human resources after 2015 to 2020 in which conventional SE may be in high demand because of large-scale system development projects mentioned earlier.

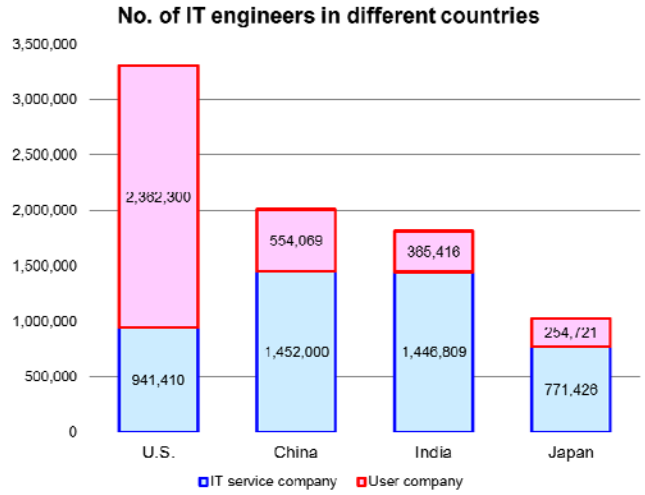
In Japan, IT human resources are unevenly distributed in the IT industry, while the IT user industry is facing a severe shortage of IT human resources. Considering full-scale operation of CPS businesses in the future, “offensive data utilization” strategically using IT/data will be promoted in the IT user industry to expand businesses and increase profits, and for this, it is necessary for user companies to internally secure personnel who can develop and implement plans for offensively using IT (so-called a producer-like person) while having a sufficient pool of management personnel who are familiar with both IT and management and can exercise leadership to promote offensive data business.

In order to respond to increased business needs in new technological areas such as Web- and cloud-related areas in addition to CPS businesses, we need an increased number of IT startup companies to create new businesses, and for this, we need an increased number of human resources who can launch a new IT startup company.

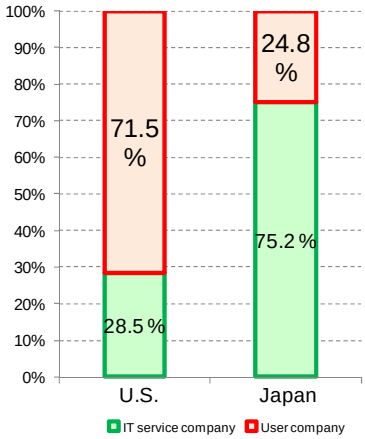
In Japan, as many IT vendors accept an order for information processing system from their outsourcers making no changes in specifications, they cannot provide new business models through the data analysis mentioned earlier. Concretely speaking, although SEs of IT vendors account for the majority of IT human resources in our country, they cannot involved in creative work due to multi-layered subcontracting system and ill treatment in the industry while IT vendors have no system to develop human resources that can support development of CPS businesses.

It is also essential to take measures for decrease in demand for IT human resources after the peak period in 2015 where many large-scale system development projects will be carried out as mentioned earlier.

<Fig. 10: No. of IT engineers in different countries>



<Fig. 11: Distribution condition of IT engineers in Japan and U.S.>



Sources: Statistical data from each company
(Bureau of Labor Statistics of U.S. Department of Labor etc.);
Known information (NASCOMM; Asian informatization report; IPA IT human resources White Paper 2010);
Others: Estimated figure based on internal service costs and "unit average salary" in "Gartner/Enterprise IT Spending by Vertical Industry Market, Worldwide, 2008-2014,2Q10 Update"

Sources: Same as on the left

On a middle- and long-term basis, business operations may use digital data and be replaced with AI in many occupations, and at the same time, recruiting young people is required to develop human resources beyond the conventional concept of IT human resources such as programmers and science-related experts (e.g. IT startup entrepreneurs, white hackers and data scientist) in middle- and long-term.

(4) Necessity of industrial system design

Industrial system design based on knowledge of engineering is important to achieve CPS. In foreign countries, for example, SEI (Software Engineering Institute) of the Carnegie Mellon University as a national research institute is working on the development of state-of-the-art software, security and improvement of business processes in U.S. In Europe, Fraunhofer Institute for Experimental Software Engineering (IESE) in Germany is making concerted efforts with domestic and overseas companies while Acatech (Akademie der Technikwissenschaften: National Academy of Science and Engineering) was established to compile analyses and advices including recommendations for achieving Industry 4.0 from the perspective of engineering in collaboration with the government and major companies.

4. Direction of measures for realizing data-driven society through CPS

In order to realize data-driven society through CPS, it is important to take advantage of Japan's strengths strategically. For instance, we have many competitive players in terms of control technologies which return accumulated, aggregated and processed data into the real world. As well, Japan's quality control has strength in "achieving high quality" in details of a system, which is advantageous when networks are becoming advanced and the importance of security is growing in areas including hardware which makes up the very networks. These strengths of Japan are realized by an abundant pool of engineers who engage in designing those technologies and taking advantage of such capable human resources could be a source of competitiveness in CPS business which is expanding from cyber to the real world. We also enjoy one of the world's most superior network environments made of optical fiber lines, etc. in terms of the FTTH penetration rate and the communication speed. Furthermore, home smart meters are scheduled to be installed in all the 50 million households in Japan by FY2024. All these show that Japan has relatively better network infrastructure for realizing data-driven society through CPS.

Such strengths could lead to creation of Japan's own CPS business models if combined with strengths of others, and it is possible to generate a virtuous cycle where data and knowhow acquired in the new business models would be used for further business development.

In order to realize this, it is crucial to develop institutions compatible with the structural change, promote a reform of industrial practice, and prepare complementary infrastructure, for which the direction of specific measures to be taken is discussed in the following.

4.1. Changing the institutions incompatible with CPS

(1) Revising the institutions/ regulations incompatible with CPS

The realization of CPS and necessary revolutionary business models should not be left up to the efforts of individual leading companies but the existing business regulations and other systems that do not go along with the latest technologies, etc., including legal measures should be reviewed in order to promote building of relevant ecosystems. For instance, new business models with new technologies could infringe existing regulations as seen in the relationship of automatic driving and the Road Traffic Law, or sharing business and conventional business laws.

As well, some companies feel hesitant about utilizing data due to their concern over security and privacy. Thus, new systems and legal measures to promote data sharing between relevant parties should be discussed, for instance, in the area of highly public or novel research and development.

Based on all these, a discussion is needed about the enhancement of functions of the Act on Facilitation of Information Processing and the Information-technology Promotion Agency (IPA) to achieve a conclusion during this fiscal year with an aim to revise regulations into new rules compatible with data-driven society through CPS and build a new legal framework and an operation system.

(2) Developing an international framework compatible with digital economy

Because data and CPS business cross the border naturally, if there are unclear rules in terms of the scope of applicable laws in different countries, protection of data-related rights and intellectual property rights, taxation, and security it could obstruct companies' global activities and lower Japan's international competitiveness. For this reason, based on dialogues between governments and international discussion, a discussion is needed on the balance between freedom of relocation/ border crossing of data and appropriate protection; how to apply legal regulations for CPS business outside the country; how to enforce the laws ultimately; and the appropriate treatment of a data monopoly under competition laws.

4.2. Driving industrial activities compatible with CPS by promoting speedy efforts

(1) Creating specific industrial models and gradually introducing soft rules in various areas in advance

While liaising with related government ministries and agencies and promoting formation and demonstration of a large-scale information infrastructure promptly, the necessity of a reform of regulations and institutions for a variety of industries and business models should be tested by utilizing special districts in order to design specific industrial models to realize CPS and commercialize them. As well, issues related to research and development should be sorted while measures to address security and privacy challenges should be discussed. Based on this, user-initiated soft rules (standard/ privacy/ security, etc.) should be developed. As well, environment should be developed where business can be operated in terms of return on investment while demonstrating effectiveness of information infrastructure to the industrial world through the previously-mentioned creation (design/ demonstration) of industrial models. These efforts should drive a reform and companies willing to develop their business will take the initiative in establishing and expanding eco-systems of CPS business.

(2) Promoting creation of CPS business through cooperation of companies

During this year, (what is tentatively called) “Council for CPS promotion” should be established to arrive at cross-industrial problem solutions based on the aforementioned industrial models by promoting cross-industrial understanding of the future direction of CPS development based on business models and technological innovation in and outside Japan and the direction of efforts to achieve it.

This Council should invite cooperation of industry, government and academia which encompass companies, including startups proactively pursuing CPS business, and individuals of learning and experience. There, industrial models to demonstrate in each sector should be designed with an outlook of future data coordination among different sectors. As well, cross-industrial rules (various soft rules, privacy guidelines, etc.) should be developed which are not affected too much by industrial models of any specific sector by considering results of demonstration of industrial models of each sector and business needs of uninvolved companies. More specifically, in order to create “data distribution market”, a standard contract model should be developed during this fiscal year to promote coordination and sharing of data among companies. At the same time, support should be provided for handling of international standardization of big data and IoT which is currently being discussed in ISO/ IEC/

JTC1 while business matching between major enterprises and startups should be promoted.

(3) Drastically enhancing environment for CPS endeavor of major enterprises and startups

Companies should be encouraged to change their IT investment activities from “defensive IT investment” which is centered on cost reduction to “offensive IT investment” to create added value, at the same time, a mechanism to drive offensive data-based management should be developed in which management strategies and utilization of IT and data are integrated. More specifically, in order to help change companies’ activities through stock exchange and further efforts of “Offensive IT Management Brands” which have already been jointly launched with the Tokyo Stock Exchange, new indices to show the degree of offensive data-based management of companies should be developed, through which businesses will be encouraged to disclose information on their offensive data utilization and IT investment at the time of announcing management plans to investors. As for medium and small companies, an IT utilization self-diagnostic tool for them should be developed in order to promote offensive IT management while a system should be built to support their data-based management by having assisting institutions including regional financial organizations and professionals work together with IT consultants such as IT coordinators.

The development of CPS is expected to bring company management closer to IT, which will lead to a variety of management styles. Thus, it is necessary to continue research on relations between data utilization and ROE/ business growth based on data and evidence and revise and examine tools including indices of communication and brands as well. For this reason, based on CPS, “Actual Conditions Survey of Information Technology”, which is a statistical survey on companies’ IT utilization, should be drastically revised and an experimental study on relations between management and IT should be promoted in cooperation with the business circle. As well, developing managerial talent including that for executives and raising their awareness should be promoted in collaboration with the business circle and universities.

Environment should be developed where startups could grow as a game changer which creates a totally new business model through CPS. For this purpose, it is crucial to implement successive measures such as “discovery and development of talent for entrepreneurs and creators”, “promotion of new businesses and startups”, and “support to put startups on a growth path in cooperation with major enterprises” as a new company is launched and grows.

For discovery and development of talent for entrepreneurs and creators, “Exploratory IT Human Resources Project (The MITOH Program)” should be enhanced so that it could cover not only software development but also innovative product and business development utilizing IT. For enhancement of talent discovery, further cooperation with universities and research institutions in and outside Japan should be encouraged. In the meantime, for further development of human resources, a new financing scheme should be introduced so that companies could return profits in the form of stock options, which could greatly facilitate start of business.

As for promotion of new businesses and startups, support should be provided for formation of networks of entrepreneurs and innovators and development of private startup accelerators made of those who have successfully launched a company in order to generate a virtuous cycle where “entrepreneurs develop new entrepreneurs”. At the same time, further cooperation with municipalities which are actively promoting startups should be encouraged while the supply of risk money at the time of startup should be increased through cooperation between the public and private sectors. Further support should be provided through the purchase from startups by national and local governments as well as other public institutions.

With regard to support to put startups on a growth path in cooperation with major enterprises, the previously-mentioned Council for CPS promotion (tentative designation) should view startups as key players, aiming to help further cooperation between the new companies and major enterprises through its activities. As well, utilization of the Innovation Network Corporation of Japan should be reviewed to realize further support for companies which aim to provide a platform in CPS business.

Lastly, a discussion is needed for formation of a preliminary consultation system with experts so that startups could take advantage of it and would not feel daunted by legal regulations related to privacy and other issues when they try to develop innovative business utilizing IT.

4.3. Creating a common base for CPS shared by the public and private sectors as a national strategy

(1) Reinforcement of corporate cyber security measures led by government

For promotion of security measures against advanced cyber-attack in the private companies, management needs to understand cyber risk, make decisions on investment of management resources in facilities, system development, human resources development, etc., and aim to improve organizational capabilities. To help this, guidelines which cover the following should be developed and announced during this fiscal year.

- Cyber security measures in anticipation of the advent of CPS
- Systems necessary for security-based management
- Technological measures to be taken based on the method of the latest cyber-attack and damage caused
- Information disclosure for stakeholders including market to make appropriate assessment/ information disclosure at the time of encountering cyber-attack

As well, a discussion is needed on an objective evaluation mechanism with a third-party certificate (“visualization”) for companies’ efforts, including those for the above guidelines, during this fiscal year, the result of which should be implemented starting the following fiscal year. In that regard, a system which can be easily used by medium and small companies should also be considered. As well, efforts should be made to make the certificate an international standard. The discussion should also cover how to utilize the certificate in risk financing market.

Due to the advent of CPS, many and variety of companies will be connected with each other, thus, sharing cyber-attack information will be of great importance. However, cyber-attack information could contain sensitive information related to business operation. As a result, companies tend to keep it to themselves. For this reason, a framework should be built which will facilitate collecting and sharing of cyber-attack information across different industries through cooperation between the public and private sectors.

For areas of important infrastructures, “Initiative for Cyber Security Information sharing Partnership of Japan (J-CSIP)” has already been formed around IPA. Its coverage should be expanded to other industries as well.

To increase companies’ emergency-response capabilities against cyber-attack, a discussion should be held to start reinforcing this fiscal year the functions of “Cyber Rescue and Advice Team against targeted attack of Japan (J-CRAT)”, through which

IPA helps government-affiliated agencies and industry groups with early restoration and recurrence prevention.
As well, support should be provided for activities for international standardization of specifications, based on which the Control System Security Center (CSSC) implements security authentication, in IEC while environment for promotion of security-related industries should be developed.

(2) Strengthening technological development

For early establishment of fundamental technologies necessary for realization of CPS, efforts should be focused to accumulate the word's latest technologies and knowledge in Japan. For that, industry, government and academia, should work together and conduct research and development to create innovative technologies which could bring about paradigm shift such as development of artificial intelligence, a core technology; advancement and lower power consumption of concentrate and distributed processing of data; security enhancement; improved performance of devices including sensors and memories; and establishment of advanced production technologies.
In particular for artificial intelligence, a research center should be established in the National Institute of Advanced Industrial Science and Technology. The research center aims to provide a platform function which creates a virtuous cycle among practical application of AI, creation of startups, and development of basic research by inviting a variety of AI researchers – from those young and energetic to top scientists – and advanced technologies from Japan and around the world, utilizing big data of the real world, and developing cutting-edge AI technologies.
With regard to data processing and research and development of devices, open innovation of Japan origin should be encouraged which will cross the borders of sectors and industries with development of a technology library, central control of related intellectual property, international standardization, and coordination for businesses, based on the results from joint research by industry, government, and academia.
The following show possible specific subjects for technological development

<Artificial intelligence (AI)>

- Brain-type AI (deep learning, etc.)
- Data-driven/ knowledge deduction integrated AI
- Non-von Neumann-type computing (quantum annealing, brain-type computer), etc.

<Data processing>

- Edge computing (distributed processing, data-centric computing)
- Real-time control technologies
- Image recognition/ processing technologies
- Advanced security technologies (data security, next-generation cryptographic technology, and control security), etc.

<Devices>

- Parasitic/ energy-saving/ high-performance sensor system
- Next-generation power semiconductors (new materials)
- Energy-saving/ high-performance semiconductors with new materials/ new structures
  (Large-capacity and high-speed memory devices/ storage systems, optical electronic devices, etc.)
- Manufacturing and design technologies realizing production with low cost/ wide variety and low volume/ improved yield, etc.

(3) Securing and developing human resources for growth of CPS business

(i) Promoting use of foreign talent

For IT human resources of which a serious shortage is expected, employment for foreign talent should be encouraged. For this purpose, study and employment in Japan should be promoted of students from IT-related universities overseas by clarifying the visa requirements for foreign IT talent and establishing an assisting organization. To attract highly capable IT human resources from other countries, in particular India, Vietnam, and other South Asian and ASEAN nations, intergovernmental talks for cooperation should be held. These efforts should be made to achieve 60,000 foreign IT workers engaged in information and communication industry in 2020, double the current employment level of 30,000.

(ii) Developing human resources in the conventional IT industry

To encourage a change in the subcontract structure of the conventional IT industry, a discussion is needed on promotion of development of human resources well versed in project management and reeducation related to the latest IT technologies.

(iii) Developing human resources in user industries

To promote the future expansion of CPS business, user industries need to take the initiative in planning IT utilization. For this, the most important element is management executives who are well acquainted with both IT and business and those who support them by playing the role of a producer. More training opportunities for IT and business skills should be provided in order to develop executives in user companies who transcend the framework of arts and sciences.

The expansion of CPS business will also need talent who can connect IT skills and other types of skills, for instance, hybrid talent with legal or financial and IT capabilities who can deal with legal issues posed by an unprecedented business model, or, in the scene of built-in software development, persons who can relate IT skills to manufacturing skills (mechanical engineering). A discussion is needed on measures to develop talent who can meet such needs.

As well, from the viewpoint of development of human resources for data security in user industries, efforts should be made to introduce a security management examination.

(iv) Developing younger talent

While encouraging the private sector's effort to further develop programming capabilities by starting at a young age, the use of the OSS community should be promoted in terms of securing and developing human resources for advanced software development. As well, based on the indication that women are likely to perform a greater role in the new CPS business than in the conventional IT business, a discussion is needed on promotion of women's greater involvement in this area.

Based on the above, a discussion should continue in the WG on Human Resources under Information Economy Subcommittee with regard to medium- and long-term human resources development necessary for CPS business to get into full swing. At the same time, revision of the Information Technology Engineers Examination should be made by clarifying the types of persons and their skills newly required in CPS business.

(4) Enhancing productivity and competitiveness of the IT industry

To support a change of the structure of the IT industry into one with higher productivity and competitiveness, efforts should be made to make subcontract deals fairer by preventing lump-sum subcontracts, which are inefficient, entail high security risk and are a cause of poor labor environment for IT workers. More specifically, it should be clearly articulated that thrusting risk and cost onto vendors in IT system deals constitutes an abuse of a superior bargaining position and violates the Subcontract Act and the Antimonopoly Act, through revising the “Guidelines for the Promotion of Fair Subcontracting Practices in the Industries of Information Service and Software” during this fiscal year among other efforts. Furthermore, security-related supervisory responsibility of ordering parties should be clarified in the previously-discussed guidelines for security-based management so that recommissioning without the authorization of the ordering party would be prevented.

As well, measures should be taken to ensure strict enforcement of the Subcontract Act and reinforce the consulting system so as to improve the effectiveness of the subcontract guidelines, etc. A model contract, which shows an ideal contract between ordering parties and vendors, should also be revised.

(5) Developing a base for industrial system design

For analysis of impact of the realization of CPS in Japan on industrial structure and promotion of building an industrial system framework, an organization should be established which is modeled after the previously-mentioned ACATECH of Germany, etc. This organization will conduct a survey analysis on technology and business trends related to CPS in and outside Japan, do a research study on systems engineering, compile recommendations on actions required for the public and private sectors, and take the initiative in standardization in the area of systems engineering.

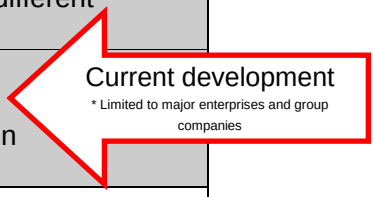
5. The current status of major areas and their efforts

The following discusses the current status and the future direction of efforts regarding seven representative areas where notable CPS development is expected to take place and, at the same time, is considered to bring a significant change in the society as a whole: manufacturing process, mobility, distribution, smart houses, medical care/ health, infrastructure/ industrial safety, administration. What is discussed here should be further examined, as needed, in accordance with the actual trends of business and technologies.

Apart from the above seven areas, future discussion and efforts are required for a variety of areas such as education, the agriculture, forestry and fisheries industry, transportation, finance, advertisement, and tourism because they are also expected to change significantly with the advent of CPS.

5.1. Manufacturing process

Cyber system (World of information)	Level 1 Digitization of the real world	- Digitization of design development - Collection of operational data of manufacturing process and products
	Level 2 Distribution of data	- Cross-process sharing of data as in design and production - Mutual use of data in different sections of a supply chain such as factories and companies, and creation of new added value through cooperation among different industries
	Level 3 Data accumulation and processing	- Standardization of data format across different processes and companies - Process improvement through visualization of acquired data
Cyber physical system (World of information and control)	Level 4 Feedback of the results of data analysis to the real world	- Design process innovation by developing a model base - Realization of flexible production process in accordance with the market needs, and highly energy-efficient production process - Feedback of maintenance/ inspection data to design development - Total solution service offering efficient product operation, maintenance/ inspection services, etc.
	Level 5 Value creation through AI and complete autonomization	- Building an advanced forecast model through data accumulation and analysis using AI



<Vision to realize>

Thanks to data sharing across processes in factories, the product life cycle (design/ production/ sales) will be more efficient and flexible, realizing shorter time-to-market of

a variety of complicated products. As well, data sharing among different companies will lead to optimization of a supply chain, realizing production and quick delivery of small quantity of many kinds at low cost.

<Challenges to overcome>
Raising awareness of Japan's manufacturing industry which grew based on a closed strategy, and building a consensus among companies for data sharing

<Direction of future efforts>
In order to establish connection among factories and companies, the in-factory control network built for factory automation in the past should be connected to the backbone network (internet). At the same time, the whole supply chain should be optimized through realization of mutual coordination and data use by clarifying the areas of competition and cooperation between companies; and removal of waste in each sector from marketing, product development to inventory management.
More specifically, the following should be implemented: (i) Acceleration of digitization of analog data accumulated in factories; (ii) Standardization of data format and promotion of middleware utilization for connection among devises and systems in factories and centralized control of them, and securing system integrators (SIer); (iii) Development of a data collection platform and analysis algorithm/ tools for its utilization, and securing talent capable of data analysis; and (iv) Support for international standardization related to digital manufacturing. In this particular area, standardization is well underway not only for individual products and technologies but systems as well; therefore, it is important to get involved from the early stage of discussion.
Based on the discussion in the Robot Revolution Initiative, companies and organizations should be encouraged to work together to conduct research and development and realize system linkage while guidelines for data sharing and utilization and a standard reference model in digital manufacturing should be discussed.
Additionally, here, special attention should be paid to the auto industry, which is receiving a strong request for handling of design development tasks which are growing ever more complicated due to a wider variety of products with high functionality and a shortening product cycle. In light of maintenance and reinforcement of Japan's developmental base, the area of cooperation related to promotion of model based systems engineering (MBSE) should be established regarding model distribution, advanced simulation, and unified rules for notation, while

securing wiggle room for differentiation which will be a source for competitiveness of parts manufacturers, in order to promote effective use of MBSE by auto manufacturers and parts companies including medium and small firms. Support should also be provided to human resources development and experimental efforts conducted in medium and small companies.

5.2. Mobility

Cyber system (World of information)	Level 1 Digitization of the real world	- Recognizing the surrounding situation with autonomous sensors built in cameras and radars, and providing information to drivers
	Level 2 Distribution of data	- Recognizing the situation of other vehicles and traffic lights with communication with other cars and streets, and providing information to drivers
	Level 3 Data accumulation and processing	- Providing information to drivers using a digital map (displaying information about traffic regulations and road surface condition acquired through a vehicle probe on a 3D map) as a platform - Secondary use of information for those who do not use a platform
Cyber physical system (World of information and control)	Level 4 Feedback of the results of data analysis to the real world	<Stand-alone> - The vehicle system take a single action of acceleration, steering, or braking according to the information from an autonomous sensor. (pre-crash brake systems, lane keeping assist systems, etc.)
		<Complex> - The vehicle system takes multiple actions of acceleration, steering, and/or braking simultaneously according to the information from an autonomous sensor (and a digital map, in some cases). (advanced driving support systems for express ways, etc.)
	Level 5 Value creation through AI and complete autonomization	<Limited automatic driving> - The vehicle system conducts all kinds of operation of acceleration, steering, and braking by utilizing an autonomous sensor and a digital map. However, drivers need to take place of the system when it asks to do so. <Complete automatic driving> - The vehicle system conducts all kinds of operation of acceleration, steering, and braking by utilizing an autonomous sensor and a digital map. Drivers do not take part in driving operation at all.

Current development

Current development

<Vision to realize>

Traffic accidents will drop sharply thanks to the development of automatic driving technologies utilizing not only autonomous sensors but also information from other vehicles and IT infrastructure. As well, issues such as traffic congestion and

environmental load will be alleviated and transportation support for seniors, etc. will develop. Also, with utilization of automatic driving technologies, realization of mobility will change “traveling time” to “free time”, effectively increasing people’s disposable time, thereby provide new possibilities.

<Challenges to overcome>

The areas of cooperation and competition have not been defined sufficiently clearly in Japan and each Japanese company still tends to take an action independently when European suppliers are increasing their influence and the US is going for platform business. As a result, there is a chance of Japanese automakers falling prey to competitors.

<Direction of future efforts>

The following shows possible future development accompanied by the growth of the automatic driving technologies: (i) Acceleration of development of key technologies including image recognition technologies by IT companies with strong data collection capabilities and computing power; (ii) Formation of a data platform which enables sharing of data necessary for automatic driving (digital maps, etc.) and information on vehicles across different areas; and (iii) Greater influence of European suppliers, excellent strategists for standardization.

(i) Acceleration of development of key technologies by IT companies

There is a possibility of IT companies with strong data collection capabilities and computing power playing a prominent role in developing image recognition technologies, key to automatic driving, by taking advantage of deep learning, etc. In fact, there has been a huge leap in image recognition technology overseas made possible through the use of data.

A discussion is needed in Japan as well on preparation of environment to promote effective research and development in this area by Japanese industry and academia including development of a driving video database which can be widely used by industry including startups and universities/ research institutions.

(ii) Formation of a data platform

Companies in Europe and the US are actively working towards development of a data platform which enables sharing of data necessary for automatic driving (digital maps to estimate the vehicle's position, for instance) and information on vehicles across different areas. Some people are concerned that de facto standardization might take place without Japanese companies' participation.

In Japan, efforts should be accelerated, with cross-industrial cooperation, to produce and examine a prototype of a digital map which is indispensable for automatic driving while a discussion should be promoted on future business models. At the same time, the importance of cooperation with other countries needs to be borne in mind through international standardization efforts. As well, a discussion should continue on how to ensure security and safety upon the use of data and how to handle personal information while keeping up with the overseas trends.

(iii) Greater influence of European suppliers

European suppliers are increasing their competitiveness in this area by learning the needs upon the use of automatic driving technologies in advance, taking the lead through technological development based on astute use of standardization and strategic establishment of criteria, and taking advantage of their strength in system development capabilities.

Because actual utilization of automatic driving technologies requires a greater degree of cooperation in the industry, among different sectors, and/or between industry and academia than the conventional automobile technologies did, making use of criteria and standards will have more importance. In Japan, efforts to define the areas of cooperation and competition should be accelerated as well. In the area of cooperation, auto manufacturers, suppliers, and universities/ research institutions should work together and actively participate in and contribute to development of international rules (criteria/ standards).

Upon the discussion on the areas of cooperation and competition, it is important for relevant parties to have common understanding of the future needs derived from the use of automatic driving technologies. A wide variety of possibilities should be considered from the viewpoint of users, such as securing means of transportation for seniors, alleviating the shortage of drivers in the transportation industry, lowering environmental load, in addition to reducing the number of traffic accidents, which has been considered the largest objective of putting automatic driving technologies to practical use. Verification projects of business models should be

implemented as needed.

5.3. Distribution

Cyber system (World of information)	Level 1 Digitization of the real world	- Digitization of product data (JAN code), product master data, and order data - Major retail businesses collect sales data through the POS system. - Digitization of data and collection of sales history with point cards and electronic money - Data collection on consumption behavior of consumers in bricks and mortar stores (analyzed through beacons and video cameras) and e-commerce websites.
	Level 2 Distribution of data	- Data distribution by individuals with the use of SNS - Distribution of digital data (order, shipment, receipt, inspection, and billing) through standardization (distribution BMS) - Collection of sales history in multiple stores by operators of a common point card program
	Level 3 Data accumulation and processing	- Order management utilizing POS data - Highly-accurate demand forecasting by using a variety of data including weather information and big data from SNS in addition to POS data
Cyber physical system (World of information and control)	Level 4 Feedback of the results of data analysis to the real world	- The spread of omnichannel through unification of customer information and inventory data of bricks and mortar stores and e-commerce websites
	Level 5 Value creation through AI and complete autonomization	- Total optimization through real-time inventory management in the whole supply chain of manufacturing, wholesale, retail, and logistics based on the advanced forecast of demand - Building an efficient distribution system with the use of robotics and automation technologies

Current development

<Vision to realize>

The form of selling will change from “mass production, mass distribution, and mass selling of standardized articles” to “selling articles which suit the individual’s tastes with no lead time”.

<Challenges to overcome>

Improvement is needed on the currently insufficient data sharing across different phases of a supply chain such as manufacturing, wholesale, retail, and logistics and among companies. An efficient distribution system which enables resource sharing needs to be built as well.

<Direction of future efforts>

In order to bring about a “distribution revolution” through consumer intelligence, improvement should be made to the efficiency of the whole supply chain of manufacturing, wholesale, retail, and logistics by developing the right environment which enables standardization for data coordination and other efforts in the area of cooperation while maintaining rivalry in the area of competition including acquisition of customer information

While utilization of various kinds of consumer-behavior data is underway mainly by major retail businesses, efforts should be made to promote the environment where medium and small companies could benefit from such data as well.

In addition, accuracy of demand forecasts should be improved through verification projects in order to implement data sharing across the whole supply chain of manufacturing, wholesale, retail, and logistics and realize real-time inventory management and inventory optimization. At the same time, inefficient commercial practices such as a delivery date and return policies should be abolished to optimize the whole supply chain. For that, the “Council for cooperation among manufacturing, distribution, and retail” should conduct pilot projects, collect best practices and encourage them to be broadly adopted.

In the area of logistics, the groundwork should be laid for realization of automatic driving of platooning vehicles and a cutting-edge logistics center with an aim to build an efficient logistics system utilizing robotics and automation technologies.

As well, support should be provided for efforts of retail and logistics businesses trying to export the “distribution revolution” by implementing this efficient supply-chain distribution system overseas including Southeast Asian countries.

In order to maximize the effect of the supply chain built upon the said advanced distribution system, a platform for data coordination should be introduced which could maximize the effect of services provided by service companies which cooperate and share movement logs and accumulated transaction and purchasing data. In this regard, a discussion is needed on development of environment, in particular improvement of transaction environment, as infrastructure necessary for building such a platform.

5.4. Smart houses

Cyber system (World of information)	Level 1 Digitization of the real world	- Digitization of power consumption data by introducing cloud-type HEMS and smart meters - Collection of home appliance data through digital home appliances
	Level 2 Distribution of data	- Building a network of digital home appliances through wireless connection (Wi-SUN, Wi-Fi) and wired connection (Ethernet, PLC)
	Level 3 Data accumulation and processing	- Commercialization of HEMS, smart meters, and home appliances compatible with ECHONET LITE (ENL) - Advanced energy management (visualization of electricity, energy-saving tips) - Creation of new services beyond the realms of energy management (monitoring seniors, health care)
		- Market expansion of devices compatible with ENL
Cyber physical system (World of information and control)	Level 4 Feedback of the results of data analysis to the real world	- Change in the energy supply system due to the spread of demand response - Optimum control of energy usage in households with the use of ADR
	Level 5 Value creation through AI and complete autonomization	- Enabling consumers to use energy as they like and realizing personalized services - Optimization and automation of energy control in cities

Current development

<Vision to realize>

Low cost and stable energy supply will be realized through drastically lowering household use of energy. Electricity retailing market will grow more active with the participation of communications businesses, CATV companies, and home appliance manufacturers which try to make use of attractive new services based on power consumption data as their competitive edge

<Challenges to overcome>

Business models of smart houses require creation of attractive services based on HEMS data and the popularization of demand response in households, both of which are currently insufficient.

<Direction of future efforts>

Efforts should be made to expand the market of distributed, and energy-creating, accumulating, and saving devices which are compatible with a centralized energy system while steadily reforming the electricity system. Improvement of economic rationality for customers, development of business operators, and creation of new

services utilizing HEMS data should be promoted.

At the same time, the use of devices compatible with ENL which are required when acquiring data should be encouraged. For the low-voltage division (households), smart meters are scheduled to be installed in all the households (approx. 50 million households) in Japan by 2024. With this as a trigger, HEMS should be quickly spread. At this point, however, cloud-type HEMS should be promoted, thereby lowering the HEMS costs. At the same time, the use of compatible devices including home appliances should be encouraged by creating attractive new services.

As well, guidelines should be developed for standardization of API and data processing/ security in order to build a large-scale HEMS database (data platform). In particular, for standardization of API, the right balance should be achieved between simplicity and expandability so that a variety of businesses could create attractive services. Currently, companies are hesitant in using big data aggressively because of a fear of being socially criticized in relation to privacy issues. To promote big data utilization, a manual for data handling, which is a guideline to be used by companies when conducting business, should be developed as well while considering the consumers' concern by striking a balance between protection of privacy and promotion of data utilization.

Additionally, efforts should be made to help create attractive services utilizing HEMS data and businesses offering such services. More specifically, creation of world's first attractive services utilizing HEMS data should be promoted, such as a senior monitoring service, which will be a differentiating factor in the electricity retailing market. As well, necessary groundwork should be laid by discussing demand-response guidelines and legal measures and conducting verification projects for attractive service creation by startups.

In the medium and long term, support should be provided for expansion to overseas market with advanced energy-saving technologies through automatic control of home appliances, services utilizing HEMS data, and a data platform including devices compatible with ENL.

As for acquisition and utilization of power usage data which is logged when home appliances and other devices are used at home, it could help develop new services which make life easier according to the resident's attributes and lifestyle inferred on such data. Realizing these services requires the increase of ENL-compatible devices and expansion of controllable range, for which the necessary environment should be prepared.

5.5. Medical care/ health

Cyber system (World of information)	Level 1 Digitization of the real world	- Data collection using wearable devices, and health promotion and management services based on such data - Digitization of health checkup data - Digitization of prescription data through the use of an Electronic Medication Notebooks System - Compiling a database of prescription and special health checkup information - Digitization of diagnostic information through Diagnosis Procedure Combination (DPC)
	Level 2 Distribution of data	- Promotion of data distribution between medical institutions and cooperation outside hospitals (regional medical cooperation)
	Level 3 Data accumulation and processing	- Building the system of Kenporen (National Federation of Health Insurance Societies) (data analysis of prescription and special health checkups) and the Kokuho (National Health Insurance) database (KDB) - Building the National Database (NDB)
		- Integrating and linking medical information
Cyber physical system (World of information and control)	Level 4 Feedback of the results of data analysis to the real world	- The spread of new health care services utilizing health information (biological information, etc.) and genomic data - Industrial usage of medical and health data (utilization of DPC data to support development of new safe and effective drugs) · Increasing IoT-compatible medical devices · Making medical care more efficient through robotization and realization of remote diagnosis/ treatment - Development of a project for setting reasonable medical charges through the use of NDB and evaluation after its implementation
	Level 5 Value creation through AI and complete autonomization	- Realization of preventative medicine and personalized medicine using health and medical data - The advent of new services utilizing health information (real-time biological information, etc.) - Raising efficiency of and advancing medicine through a diagnostic aid system utilizing AI. - Development of innovative new drugs and regenerative medicine

Current development

<Vision to realize>

Focus of people, companies, and insurers in the area of medical care and health will shift from “treatment” to “prevention”. This shift in consciousness will make people healthier and everyone from working generation to senior citizens will become more active. It will also bring social costs including medical expenses down to reasonable levels.

<Challenges to overcome>
Although it is necessary to use health data and medical data in a unified manner, data integration and development of environment for the use of such data is not sufficient.

<Direction of future efforts>
“Healthy life expectancy” of people should be extended. To achieve this, environment should be developed where health data (real-time biological information, etc.) and medical data (prescription/ health checkup data, etc.) could be jointly utilized while efforts should be made to create new services to maintain good health, and advance and raise the efficiency of medicine by taking advantage of the big data.
First, environment should be developed for utilization of health data so as to create new health care services. More specifically, insurers including health insurance societies and companies should cooperate and accelerate discussion of how to collect and utilize data from a perspective of users in the “Next-Generation Healthcare Industry Council”. What kind of health data in what unit is necessary for health management (with a prospect of future integration with medical information) should be clarified through the initiative of three parties: businesses conducting health-based advanced management which are the main users of health data; insurers including health insurance societies; and service companies providing health care services. Based on the result of this, the above interested parties should collect and use data through a verification project, thereby develop rules necessary for health data usage and discuss measures to roll it out to other insurers, etc.
Second, environment should be developed where medical data could be utilized, including ensuring cooperation in and outside hospitals. Specifically, acceleration of a discussion is required with regard to digitization of medical data including medical ID, rules for its collection and analysis, and formation of a framework in “Next-Generation Medical ICT Infrastructure Council”.
As well, a discussion is needed on the potential usability of DPC data for development of new drugs as provision of DPC data to a third party has been experimentally started.
Additionally, advanced medical devices should be developed. More specifically, in the “Next-Generation Medical Device Development Promotion Council” and the “Next-Generation Medical ICT Infrastructure Council”, development of medical devices and systems should be promoted which will enable analysis and utilization of medical data such as diagnostic data and treatment data.

5.6. Infrastructure/ industrial safety

Cyber system (World of information)	Level 1 Digitization of the real world	- Collection of safety big data* (operation data/ maintenance data) of plants, etc. * Including numerical data of temperature and pressure of fluids, digital video data from surveillance cameras, and a variety of text data such as close calls, operation records, business logs, etc. - Collection of accident data held by administrative agencies, concerned bodies, and businesses - Introduction of IT devices and operation systems to work sites
	Level 2 Distribution of data	- Sharing safety big data (operation data/ maintenance data), accident data, and best practices of plants across divisions and different organizations
	Level 3 Data accumulation and processing	- Developing a database and conducting analytical processing for utilization and analysis of big data (operation data/ maintenance data) in the area of infrastructure maintenance and safety - Developing a safe and efficient operation process, and maintenance/ renewal plans according to the degree of deterioration of the facilities based on the analysis
Cyber physical system (World of information and control)	Level 4 Feedback of the results of data analysis to the real world	- Most suitable maintenance and facility renewal based on the above plans as well as construction of low-cost and highly-efficient infrastructure - Complementing judgement of plant operators regarding safety management through monitoring of correlation in safety big data (operation data/ maintenance data) - Repairing plans and conducting preventative maintenance based on the forecast of the location of malfunction through analysis of safety big data (operation data/ maintenance data)
	Level 5 Value creation through AI and complete autonomization	- Establishing sustainable infrastructure flexible enough to deal with a change in supply and demand caused by weather conditions and demographic movement - Realizing advanced self-maintenance which, based on real-time data, forecasts deteriorating and weak parts of facilities which might lead to a serious accident and enables selective and preferential treatment

Current development

<Vision to realize>

Sustainable operation of public infrastructure including that in underpopulated regions will be realized thanks to heightened operational efficiency. At the same time, the efficiency of social infrastructure will further increase through area expansion of public infrastructure projects and increase of the public finance initiative (PFI).

As well, the improvement of safety levels with the use of new technologies will make it more certain that objectives of regulations (prevention of accidents) should be achieved, thereby increasing productivity through shortening the period of plant

shutdown for troubleshooting and legal inspections. At the same time, it will lessen the burden on businesses which are conducting highly strict self-maintenance.

<Challenges to overcome>
Both digitization of data and analysis of big data are insufficient. A wider variety of data usage should be discussed.

<Direction of future efforts>
Methods should be discussed to raise the efficiency of maintenance operation of infrastructure through the introduction of IT systems, data analysis, and the use of common specifications.
Special attention should be paid to water supply businesses, which are mainly operated by local governments. Currently they are facing a variety of challenges including deterioration of facilities, worsening profits due to shrinking water-supplied population, and reduced staff because of resignation of baby boomers. For this reason, sustainable water supply systems should be realized by establishing standard specifications of water business which provides stable supply of water at low cost and rolling them out to water businesses in the country.
Specifically, in order to renew old facilities and normalize their scale in accordance with the change in supply and demand, optimum facility renewal plans should be developed through accumulation and analysis of facility operation data by using sensors, and promotion of digitization of facility information and records of maintenance and inspection. As well, in order to continue stable business while staff gets older and experienced employees resign, digitization of business operation knowhow, implicit knowledge, and its rollout to fellow businesses should be implemented in addition to efforts to improve operational efficiency through the introduction of IT devices including sensors and tablet computers. For cost reduction of facilities and systems, specifications should be standardized as well, thereby promoting competition among vendors and joint development of facilities.
The introduction of a standard operation process, standardization of facility specifications and systems, and utilization of data accumulated across different businesses may lead to possible expansion of the service area by incorporating a neighboring business or efficient operation by a private company if necessary.
In the future, Japan’s water businesses should expand to the growing water business market overseas. At the same time, they should aim to raise the efficiency of the whole social infrastructure by rolling out the experience and knowledge acquired through water projects to other infrastructure.

As well, regulations should grow “smart” and enable flexible and effective usage of new technologies so as to help maintain and improve industrial safety levels and eradicate serious accidents.

More specifically, the conventional industrial safety which is focused on accident response and regular maintenance should be upgraded into that which is centered on accident prediction and preventative maintenance made possible with the use of big data analysis technologies. For this purpose, “operation data (temperature and pressure of fluids)” and “maintenance data (corrosion, troubles, etc.)“, both of which are accumulated every day in factories including oil refineries and chemical plants but remain unused, should be digitized, and research and development should be promoted for sensors and processing/ analysis technologies to be used for data sharing and analysis in and outside the company, while a verification project should be implemented to discuss maintenance and safety using digital video data from surveillance cameras. As well, the introduction of incentives should be examined as a way to motivate accomplishment of a high-level self-maintenance target using new technologies.

Furthermore, to promote the use of big data including accident data accumulated in a variety of forms by administrative agencies, industry groups, businesses, etc., a technical platform related to analysis and processing of a large volume of text data should be reinforced and introduced.

5.7. Administration

Cyber system (World of information)	Level 1 Digitization of the real world	- Data management through collection and machine translation of patent documents and technical literature in foreign languages - Building a large-scale statistical system and providing online services
		- Databasing business information of administration
	Level 2 Distribution of data	- Opening public data (open data) - Providing government statistics online across administrative organizations (e-Stat)
		- Databasing business information in administrative organizations - Information sharing across administrative organizations and between the public and private sectors
	Level 3 Data accumulation and processing	- Researching prior art documents as preliminary inspection for patent examination, refining machine translation of patent documents in foreign languages, and advancing data search functionality - Collection of big data which help refine statistics depicting B to C activities. - Combined management of outsourced statistics data though the use of cloud environment
Cyber physical system (World of information and control)	Level 4 Feedback of the results of data analysis to the real world	- Realization of faster report of statistics through the use of big data, refinement of data, diversification of analyses, and cost reduction of data aggregation
	Level 5 Value creation through AI and complete autonomization	- Real-time economic indicator (nowcasting), and prediction of the future based on information (business confidence, etc.) sent out by individuals and businesses (forecasting) - Raising efficiency of examination for approval and authorization using AI, etc.

Current development

<Vision to realize>

With the use of big data and AI, the effectiveness of administration will advance drastically and more value will be added through reduction of inspection cost, realization of faster statistics report and improved convenience, and heightened efficiency and accuracy of examination for approval and authorization.

<Challenges to overcome>

Discussion is insufficient with regard to specific methods of utilization of big data and AI which will realize high value-added administration services and drive private businesses.

<Direction of future efforts>

Utilization of data in administration will help promote private businesses through development of new indices and provision of public data as well as drastically improve business efficiency in administration, and realize high value-added administration services as a result of value creation through data analysis.

In the area of statistics, economic indices enabling quicker report should be developed with the analytical use of not only data collected by administration but also the private sector. For this, an experimental study should be conducted for development of new retail indices based on retail data in the private sector. As well, possibilities of developing new statistics indices based on data from SNS should be examined.

With regard to research of prior art documents as preliminary inspection for patent examination, use of machine translation systems should be promoted for patent literature of non-Western countries including China in order to further increase accuracy and efficiency. As well, with the background of rapid increase of patent literature, examination of a prototype of an accurate and efficient search system based on AI and big data analysis technologies should be accelerated for introduction of the system in a few years. Additionally, development of an advanced support system should be discussed which will take advantage of AI and big data analysis technologies for the use in various research not limited to that of prior art documents as preliminary inspection for patent examination.

To develop environment which enables efficient sharing and analysis of business data owned by administrative agencies, the Ministry of Economy, Trade and Industry will develop a search and verification system for related information in the Ministry which uses enterprise identification number scheduled to be introduced soon as a key. As well, national and local governments will expand useful open data to promote distribution of public data owned by administration and its use by the private sector. At the same time, infrastructure should be developed to enable the public and private sectors to cooperate in the use of data (that is, establishing common data structure and vocabulary, measures to ensure credibility of data users which are necessary for realizing data sharing between data compilers, and use of common IDs and codes such as enterprise identification numbers).

Additionally, in order to promote the use of new technologies in administration, verification projects should be considered to enable speedy and flexible cooperation among companies, including startups, with advanced new technologies, research institutions, and government. At the same time, government procurement systems should be reviewed as well.

6. Closing remark

Efforts for development of CPS have just begun and this is also the case in Europe and US. However, the speed of development is extremely fast and fierce competition and formation of an alliance related to building of a platform with a prospect of future monopoly profit is already underway in other countries. This means that our country's major industries could lose international competitiveness if they get a late start.

As CPS develops, however, we also have some global "advantage" such as: control technologies indispensable for feedback to the real world; quality control capabilities of "achieving high quality" in details, a necessary element in reinforcing security which is of great importance; an abundant pool of needed engineers; and network environment. What Japan is missing is, first and foremost, an approach through which companies conceptualize an advanced business model utilizing data in the midst of uncertainty, start commercializing it ahead of others, and deal with issues, if any, while running the business.

Industry, government and academia need to work together without wasting time to develop environment which promotes the advanced initiative of companies in order to strategically utilize the advantage of Japan as well. For this purpose, this Subcommittee will continue discussing necessary specific measures.

Through all these efforts, we should realize world's first "data-driven society" equipped with CPS in Japan.

Apart from the industries we discussed above, a wide variety of other sectors, including education, are expected to change as CPS develops. We do not need to stick to the conventional framework of thinking when division of industries could lose its meaning in the first place.

The advance of AI and realization of autonomy is considered to bring a huge shift in industrial structure and the whole economy and society in the future. It could cause a major change to the framework of existing industries and lead to innovation from deep levels in a wide variety of areas including the form of business operation and organizations, work and life styles, and empowerment of individuals. As a result, administration could change its form as well.

While it is hard to predict all these changes precisely, it is necessary to discuss policies in a comprehensive manner considering a variety of possibilities and work on them on a medium- and long-term basis. We hope that our argument here and measures based on it will trigger Japanese industries' efforts to prepare for the forthcoming sea change.